CHAMBER OF VALVES IN THE ARENOSO RESERVOIR

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KEYWORDS: Reservoir, Spillway, Greywacke, Clay core,

ABSTRACT
Of the south of Spain, near the province of Cordova, in a tributary of the Guadalquivir River it has been constructed during the years 2004 to 2007 the reservoir called El Arenoso.

El Arenoso reservoir that belongs to Environment Ministry is destined to downstream Guadalquivir's water supply and the general regulation of the river. The dam is located on the same name river and it is next to the Montoro's municipal district, 41 km northeast of Cordova. The main work consists on an embankment dam, with central clay core, and slates and greywacke shoulders. The core is covered downstream with a filter material and upstream with a transition material. The dimensions of the dam are 80 m high, 1.480 m long at its crest, and it has been needed more than 3 million m^3 of materials, creating a waterproof barrier able to keep 160 hm^3 as a useful reservoir.

In the zone of the core is located the chamber of valves with a horizontal clearance of 10 m and a vertical clearance of 14,517 m.

The present article exposes the most important characteristics of project and construction, of valves chamber of the Arenoso reservoir.

INTRODUCTION

Of the south of Spain, near the province of Cordova, in a tributary of the Guadalquivir River it has been constructed during the years 2004 to 2007 the reservoir called El Arenoso.

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The dam has an uncontrolled spillway its crest at the 209 level, 24 m long, and outlet flow capacity nearly 500 m^3/s with the water level placed at PMF level. The deep outlets are two circular pipes with 2.000 mm and 2.500 mm in diameter and 80 m^3/s outlet capacity with the full reservoir.

Fig. 1 El Arenoso reservoir in the province of Cordova

THE CHAMBER OF VALVES

In the zone of the core of the dam is located the chamber of valves with a horizontal clearance of 10 m and a vertical clearance of 14,517 m. The thicknesses of the lateral walls of the chamber are with a thickness which varies between 7.17 m at the base and 3.29 m on the top. The arch of the vault is of 2.50 m. width.

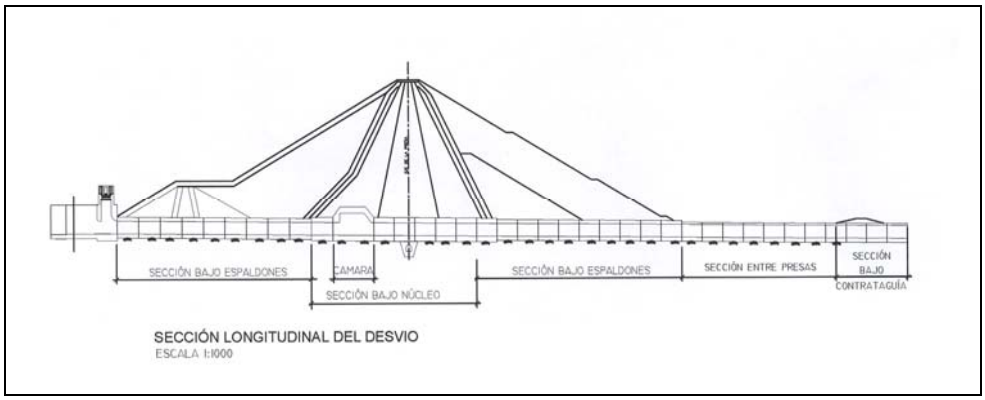

Fig. 2 Transversal section of El Arenoso dam

The average level of the top face of the slab bottom of the chamber is + 141.131 and the level of the low face of the vault of the chamber is +155.648, which it gives a maximum vertical clearance in the chamber of 14,517 m.

The interior width of the chamber is 10,00 m. having walls that have changeable thicknesses, with a maximum value of 7,17 m (left side) and 3,29 m (right side) at the bottom of the same ones, coming to a thickness at the beginning of the arch o the vault of 2,50 m.

The vault has a thickness that turns out to be lightly changeable, but it can be took it to structural effects as of 2,50 m. In the Figure 3 it can be appreciated the transversal section of the chamber of valves.

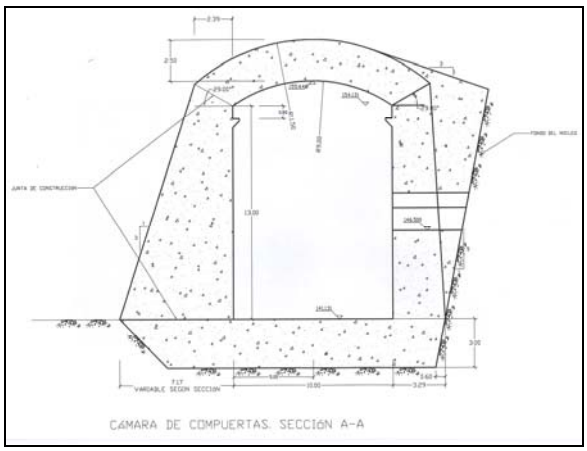

Fig. 3 Transversal section of the chamber of valves

The galleries before and after the chamber of valves have a free span between lateral walls of 8,00 m and a vertical clearance to the low face of the arch, at the top of the vault of 6,00 m. The walls of the galleries are of changeable thickness with a minimal value in the base of 3,12 m and 3,00 m.

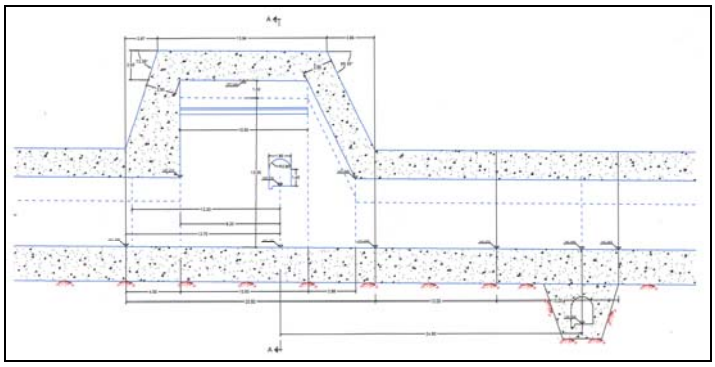

Fig. 4 Section of galleries and the chamber of valves

Finally, the thickness of the slab foundation of the galleries is 3,00 m.

THE PROJECT OF THE CHAMBER OF VALVES

The Project of the chamber of valves was realized by means of a three-dimensional model of finite elements of 535 nodes and 512 shell elements with the program SAP2000N.

It was made a parametric analysis with two subgrade modulus in the contact between the slab foundation and the soil. 1) for soft soil and 2) for hard soil, with the next values:

1. Coefficient for soft soil: K_{1b} = 49.000 kN/m^3
2. Coefficient for hard soil: K_{2b} = 4900.000 kN/m^3

In the contact between the walls and the rock it was take a horizontal subgrade modulus of K_h = 24.500 kN/m^3

Over the roof of the chamber there is 47 meters of the nucleus of the dam and 40 meters of water in the maximum normal level in the dam.

So the pressures over the roof vault of the chamber were 1826 kN/m^3. The figure 5 shows the distribution of loads over the chamber of valves of El Arenoso dam.

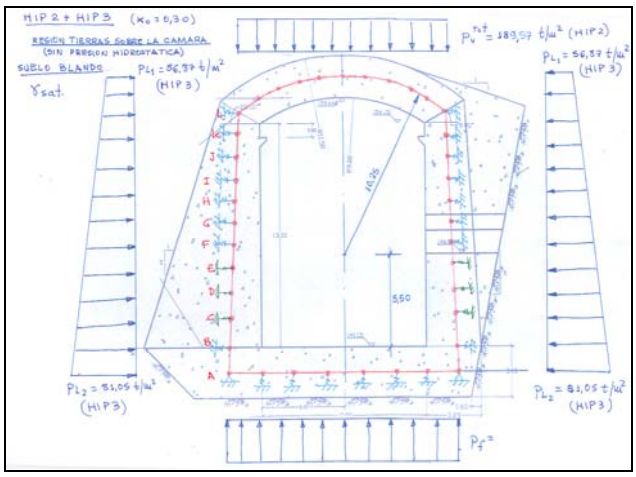

Fig. 5 Pressures over the chamber of valves

It was studied six hypothesis of load combinations, three corresponding to soft soil and the other three to hard soil.

THE RESULTS OF THE ANALYSIS

As a result of the analysis it was obtained all the axial and shears loads and all the flexural and torsional moments over the transversal sections of the galleries and at the chamber of valves. In figure 6 it is shown and exit of the SAP2000N program due to the flexural moments M11.

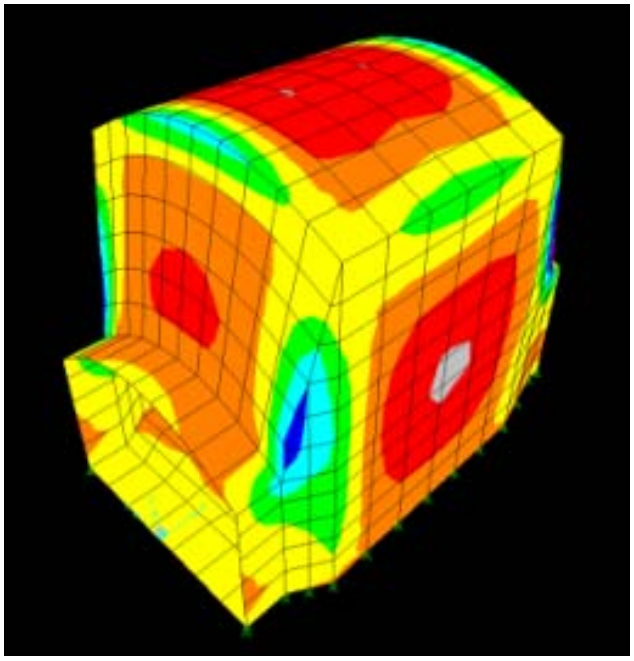

Fig. 6 Flexural moments M11 by the 3D Finite Element Model

Finally it was obtained the reinforcing bars for the galleries and the chamber.

THE CONSTRUCTION OF THE CHAMBER OF VALVES

The construction of the chamber of valves took place during the year 2005 and by the end of this year it was complete the construction of it.

In the next figures it can be seen various phases of the construction of the chamber of valves of the Arenoso dam.

Fig. 7 Construction of the outlet galleries

Fig. 8 Construction of the walls

Fig. 9 Construction of the vault

Fig. 10 The chamber of valves finished

No special problems were encountered during the construction of this structure of the dam.

CONCLUSIONS

As a result it was constructed one of the most important control organs of the El Arenoso reservoir.

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